# Preface

The discipline of dynamical system unifies the language of mathematics and physics describing its time dependency, evolution and predictability in all future. The advent of sophisticated instruments and technological devices completely scrutinize the real world from celestial objects to subatomic particles and explore some fascinating physics hidden in such a world. The problem of electromagnetic wave propagation in an ordered magnetic material is an active, interdisciplinary area of physics with countless applications ranging from atomic physics to medical imaging, remote science to signal processing, geosciences to high level data storage devices, cell phones and memory gadgets. In particular, magnetic storage devices are smart systems, quite appealing and exploit attractive dynamics through the functional role played by electrons. Electrons, the fundamental quantum entity intrinsically hold a property called *spin angular momentum* or simply *spin* through which one can obtain all the information necessary to develop novel magnetic devices. The light-spin interaction is inevitable in such a spin based electronic devices and hence investigation of electromagnetic wave interaction with the spins is the need of the hour. Though the spin is essentially a quantum entity need more comprehensive knowledge of quantum physics, there exist routes to solve the entire spin based problem in the classical limit which could be easy for the betterment of spin studies. The dynamics of such a spin system is governed by the classical equation of motion designed by Landau and Lifshitz, motivated to model the interaction of magnetic field with the magnetization developed in the magnetic medium. Subsequently, people put more effort in this line of studies and came with more interesting physical consequences, questions and solutions. Soliton based magnetic studies is one such motivating theory developed and substantial results obtained in the magnetization dynamics that are associated with solitons. The Landau-Lifshitz equation was later solved for the soliton solutions and the magnetization dynamics in the medium were explained on this basis of soliton theory. Especially, the nonlinear spin excitations in the form of solitons made significant in modern physics. Because of its vital importance and remarkable stability, soliton based magnetization reversal, logic gates, optical soliton to carry information and signal processing are few to list its applications in recent times. Motivated by the above, this thesis focuses on the nonlinear magnetization dynamics of ferro/antiferro magnetic material. Theoretical, analytical and computational studies devoted to the electromagnetic wave propagation in a ferro/antiferro magnetic medium are well explored and the nonlinear spin excitations in the medium are governed by soliton modes. The fundamental dynamical equations governing these systems are the coupled Landau-Lifshitz and Maxwell's (LLM) equations. The structure of the thesis as follows.

Survey of soliton history and its functional role in magnetism, various types of magnetic material with physically significant spin interactions and its evolution in the form of solitons are presented in the *first* chapter of the thesis.

*Chapter 2* focus on the solitonic evolution in weak ferromagnet with single ion uniaxial anisotropy is established through solving the derivative nonlinear Schrödinger (DNLS) equation. The obtained DNLS is rigorously solved by invoking tangent hyperbolic function method. Also in the same chapter, as an extension helimagnetic spin system is solved and the evolution equation is reduced to perturbed nonlinear Schrödinger (NLS) equation. The NLS equation is solved for perturbed soliton solution and soliton parameter by employing the multiple scale perturbation technique.

In *chapter 3*, spin system comprising site-dependent bilinear, biquadratic with weak ferromagnetic interaction elevated through Dzyaloshinskii-Moriya interaction is solved by reducing the coupled LLM to solvable partial differential equations through reductive perturbation method. A class of soliton spin excitations is elucidated. In addition magnetization reversal mechanism is also exploited in these classes of systems.

*Chapter 4* is devoted to solve the dynamics associated with the ferromagnetic spin system with octupole-dipole interaction. The dynamics is completely governed by perturbed NLS equation and the same is solved for perturbed soliton solution through the multiple scale perturbation analysis for magnetization reversal studies.

Breatherlike electromagnetic wave propagation in a weak antiferromagnet is completely studied in the framework of LLM equation. The DM interaction present in the system substantially enhances the amplitude of the soliton and the individual magnetization exhibit breatherlike spin modes. The above studies are compiled in *fifth* chapter of the thesis.

The *sixth* chapter of the thesis composed of two studies focusing on the one dimensional nanowire incorporating the weak DM interaction and (2+1) dimensional Heisenberg weak ferromagnetic spin chain. Both in nanowire and (2+1) dimensional spin chain, the equation of motion is governed by nonlinear Schrödinger (NLS) family of equation which is subsequently solved for soliton spin excitations.